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Amended Radio Test Report

Client:	**Johnson Outdoors** **1531 Madison Ave.** **Mankato, MN 56001**
Product:	**Ulterra with i-Pilot Standard System** **2400 – 2483.5MHz band iPilot Standard Radio**
FCC ID:	**T62-ULTERRAIP15**
IC:	**4397A-ULTERRAIP15**
Test Report No:	**R20131014-21-13A**
Approved By:	**Nic S. Johnson, NCE** **Technical Manager** **iNARTE Certified EMC Engineer #EMC-003337-NE**
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TESTING LABORATORY
CERTIFICATE NO. 1953.01

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1.0 Summary of test results

The EUT has been tested according to the following specifications:

APPLIED STANDARDS: FCC Part 15, Subpart C Industry Canada RSS-Gen, RSS-210 Issue 7 AS/NZS 4268:2008			
Standard Section	**Test Type and Limit**	**Result**	**Remark**
15.203 RSS-Gen Issue 4	Unique Antenna Requirement	Pass	Permanently attached antenna
15.207 RSS-Gen Issue 4	Conducted Emissions	NA	No connection to AC mains network
15.209 RSS-Gen Issue 4	Radiated Emissions	Pass	Meets the requirement of the limit.
15.247(a)(1) RSS-210 Issue 8	Minimum Bandwidth, Limit Min. 500kHz	Pass	Meets the requirement of the limit.
15.247(b) RSS-210 Issue 8	Maximum Peak Output Power, Limit: Max. 23.9dBm	Pass	Meets the requirement of the limit.
15.247(c) RSS-210 Issue 8	Transmitter Radiated Emissions, Limit: Table 15.209	Pass	Meets the requirement of the limit.
15.247(c) RSS-210 Issue 8	Band Edge Measurement, Limit: 20dB less than the peak value of fundamental frequency	Pass	Meets the requirement of the limit.
15.247(a) RSS-210 Issue 8	Power Spectral Density	Pass	Meets the requirement of the limit.

1.1 Reason for amendment: frequency range was corrected and all references to 15.249 were deleted. The frequency range was corrected to 2452 to 2462 MHz.

2.0 Description

2.1 Equipment under test

The Equipment Under Test (EUT) was an Ulterra trolling motor with i-Pilot Standard system controller pre-installed, which operates from 2452 to 2462 MHz. This radio is intended to communicate with an external remote (previously tested). This report is specific to this radio.

The EUT included 2 additional transceivers on the main board and on the trim board which operate between 915 and 921 MHz. These radios communicate only between one another. The test results from this radio are covered in a separate report.

EUT Received Date: 10 March 2014
EUT Tested Dates: 10 March 2014 – 16 September 2014

PRODUCT	Ulterra with i-Pilot Standard system
POWER SUPPLY	24 VDC from battery
MODULATION TYPE	FM
RADIO TECHNOLOGY	Half-duplex RF Link
ANTENNA TYPE	Internal Dipole

NOTE:
1. For more detailed features description, please refer to the manufacturer's specifications or User's Manual.

2.2 Laboratory description

All testing was performed at the NCEE Lincoln facility. Laboratory environmental conditions varied slightly throughout the tests:

Relative humidity of 26 ± 4%
Temperature of 23 ± 3° Celsius

2.3 Description of test modes

The EUT operates on, and was tested at the frequencies below:

iPilot link head

Channel	Frequency
1	2452
2	2457
3	2462

These are the only three frequencies possible iPilot Standard head.

2.4 Applied standards

The EUT uses digital modulation and operates between 2400.0MHz and 2483.5MHz. It has no provisions for connection to the AC mains connection. According to the specifications of the manufacturer, it must comply with the requirements of the following standards:

FCC Part 15, Subpart C (15.247)
FCC Part 15, Subpart C (15.209)
Industry Canada RSS-GEN Issue 4
Industry Canada RSS-210 Issue 8
ANSI C63.10:2013

All test items have been performed and recorded as per the above.

2.5 Description of support units

None

2.6 Configuration of system under test

This EUT was set to transmit in a worse-case scenario with modulation on. The manufacturer modified the unit to transmit continuously on Channel 1, 2 or 3.

3.0 Test equipment used

DESCRIPTION AND MANUFACTURER	MODEL NO.	SERIAL NO.	LAST CALIBRATION DATE
Rohde & Schwarz Test Receiver	ES126	100037	21 Jan 2014
EMCO Biconilog Antenna*	3142B	1654	13 Jan 2014
EMCO Horn Antenna**	3115	6416	14 Jan 2014
EMCO Horn Antenna***	3116	2576	31 Mar 2014
Rohde & Schwarz Preamp*	TS-PR18	NCEEPAHF20	26 Mar 2014****
Trilithic High Pass Filter*	6HC330	23042	26 Mar 2014****

*Used for radiated measurements above 3GHz
**Used for measurements above 6GHz
***Used for measurements above 18GHz
****Internal Characterization

4.0 Detailed results

4.1 Unique antenna requirement

4.1.1 Standard applicable

For intentional device, according to FCC 47 CFR Section 15.203, an intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device.

4.1.2 Antenna description

The antennas are permanently attached and internal to the EUT and not replaceable.

4.2 Radiated emissions

4.2.1 Limits for radiated emissions measurements

Emissions radiated outside of the specified bands shall be applied to the limits in 15.209 as followed:

FREQUENCIES (MHz)	FIELD STRENGTH (μV/m)	MEASUREMENT DISTANCE (m)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30.0	30	3
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

NOTE:

1. The lower limit shall apply at the transition frequencies.
2. Emission level (dBuV/m) = 20 * log * Emission level (μV/m).
3. As shown in 15.35(b), for frequencies above 1000MHz, the field strength limits are based on average detector, however, the peak field strength of any emission shall not exceed the maximum permitted average limits by more than 20dB under any condition of modulation.

4.2.2 Test procedures

a. The EUT was placed on the top of a rotating table 0.8 meters above the ground plane in a 10 meter semi-anechoic chamber. The table was rotated 360 degrees to determine the position of the highest radiation.

b. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.

c. The antenna was a broadband antenna, and its height is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are used to make the measurement.

d. For each suspected emission, the EUT was arranged to maximize its emissions and then the antenna height was varied from 1 meter to 4 meters and the rotating table was turned from 0 degrees to 360 degrees to find the maximum emission reading.

e. The test-receiver system was set to use a peak detector with a specified resolution bandwidth. For spectrum analyzer measurements, the composite maximum of several analyzer sweeps was used for final measurements.

f. If the emission level of the EUT in peak mode was 10dB lower than the limit specified, then testing could be stopped and the peak values of the EUT would be reported. Otherwise the emissions that did not have 10 dB margin would be re-tested one by one using peak, quasi-peak or average method as specified and then reported in a data sheet.

g. The EUT was measured in both the horizontal and vertical orientation. It was found that the vertical position produced the highest emissions, and this orientation was used for all testing. See Annex A for test photos.

Table 1 – Correction Factor Applied in Sections 4.3, 4.4 and 4.6

CHANNEL	CHANNEL FREQUENCY (MHz)	ANTENNA FACTOR	CABLE LOSS
1	2452	28.47	7.20
2	2442	28.47	7.20
3	2447	28.47	7.20

NOTE:
1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120kHz for Peak detection (PK) and Quasi-peak detection (QP) at frequencies below 1GHz.

2. The resolution bandwidth was 1 MHz for all measurements and at frequencies above 1GHz, The video bandwidth was 1MHz for peak measurements and 10Hz for average measurements. A peak detector was used for all measurements above 1GHz. Measurements were made with an EMI Receiver.

4.2.3 Deviations from test standard

No deviation.

4.2.4 Test setup

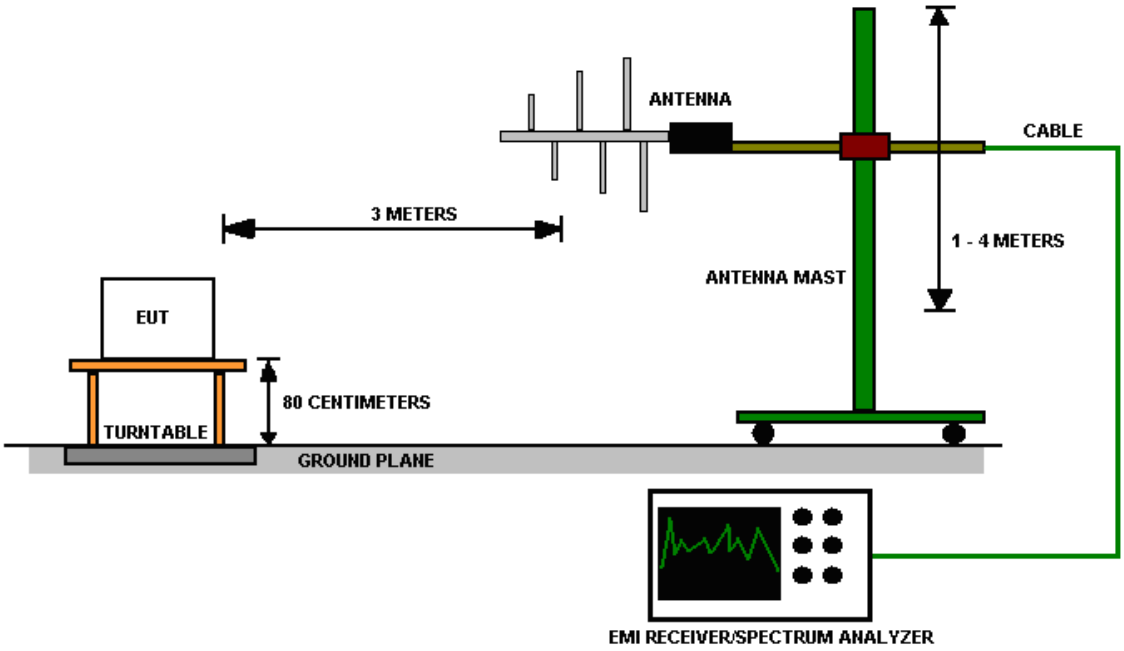

Figure 1 - Radiated Emissions Test Setup

For the actual test configuration, please refer to Appendix A for photographs of the test configuration.

4.2.5 EUT operating conditions

The EUT was powered by 24 VDC unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range.

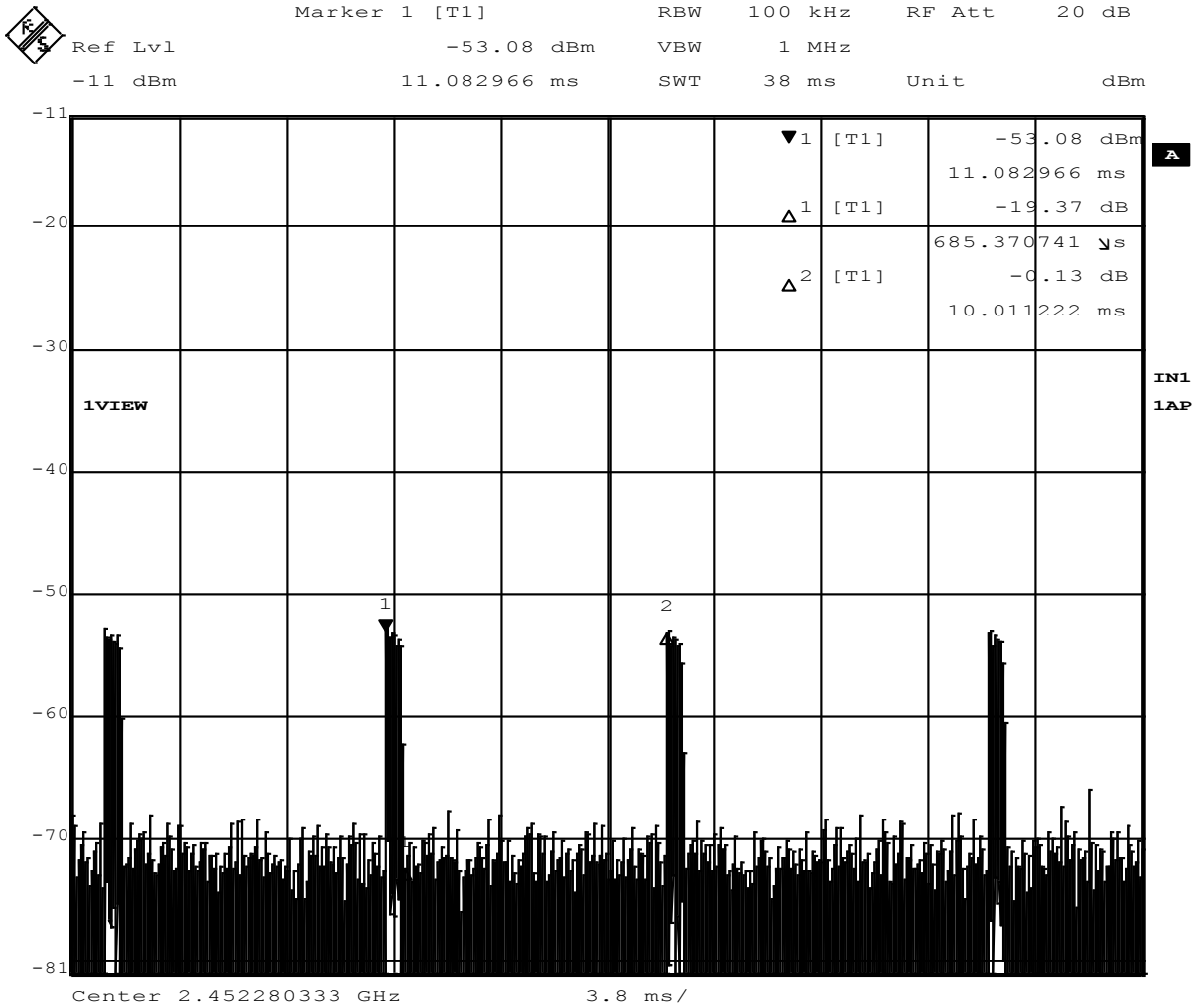

Figure 2 – Duty Cycle, iPilot Standard

20 log (0.685 mS / 10.01 mS) = -23.29

Note: Correction for peak to average measurement = 20 dB (Max allowed)

4.2.6 Test results

EUT MODULE	i-Pilot Standard Head	MODE	Receive
INPUT POWER	12 VDC Battery	FREQUENCY RANGE	30MHz – 26 GHz
ENVIRONMENTAL CONDITIONS	26 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

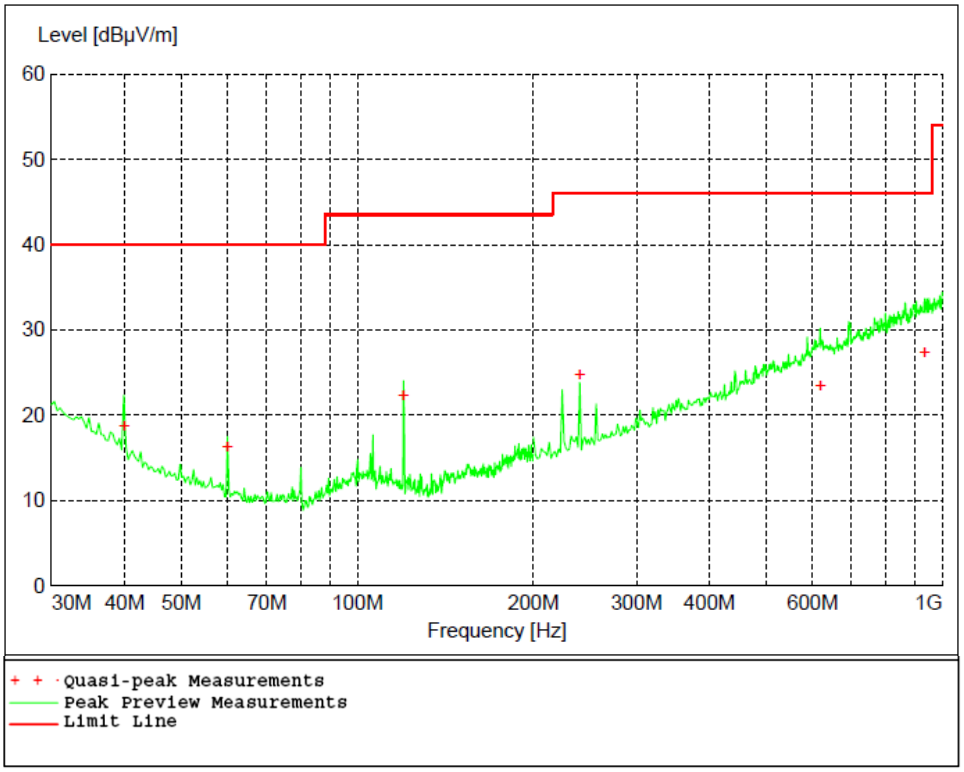

Figure 3 - Radiated Emissions Plot, Receive

Table 2 - Radiated Emissions Quasi-peak Measurements, Receive

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
39.960000	18.68	40.00	21.30	98	268	VERT
60.000000	16.30	40.00	23.70	99	75	VERT
120.000000	22.23	43.50	21.30	101	76	VERT
240.000000	24.78	46.00	21.20	183	187	HORI
619.800000	23.32	46.00	22.70	123	327	VERT
933.000000	27.38	46.00	18.60	99	358	HORI

Table 3 - Radiated Emissions Average Measurements, Receive

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
1664.800000	19.85	54.00	34.15	398	166	HORI
2447.400000	21.67	54.00	32.33	395	328	HORI
4657.800000	27.20	54.00	26.80	177	173	VERT

Table 4 - Radiated Emissions Peak Measurements, Receive

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
1664.800000	39.85	74.00	34.15	398	166	HORI
2447.400000	41.67	74.00	32.33	395	328	HORI
4657.800000	47.20	74.00	26.80	177	173	VERT

REMARKS:
1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB)
2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB)
3. The other emission levels were very low against the limit.
4. Margin value = Emission level – Limit value.
5. Average measurements were calculated from applying the averaging factors from Figures 2 – 4 to the peak measurements

EUT MODULE	i-Pilot Standard Head	MODE	Transmit, Ch 1 2452 MHz
INPUT POWER	24 VDC Battery	FREQUENCY RANGE	30MHz – 26 GHz
ENVIRONMENTAL CONDITIONS	26 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

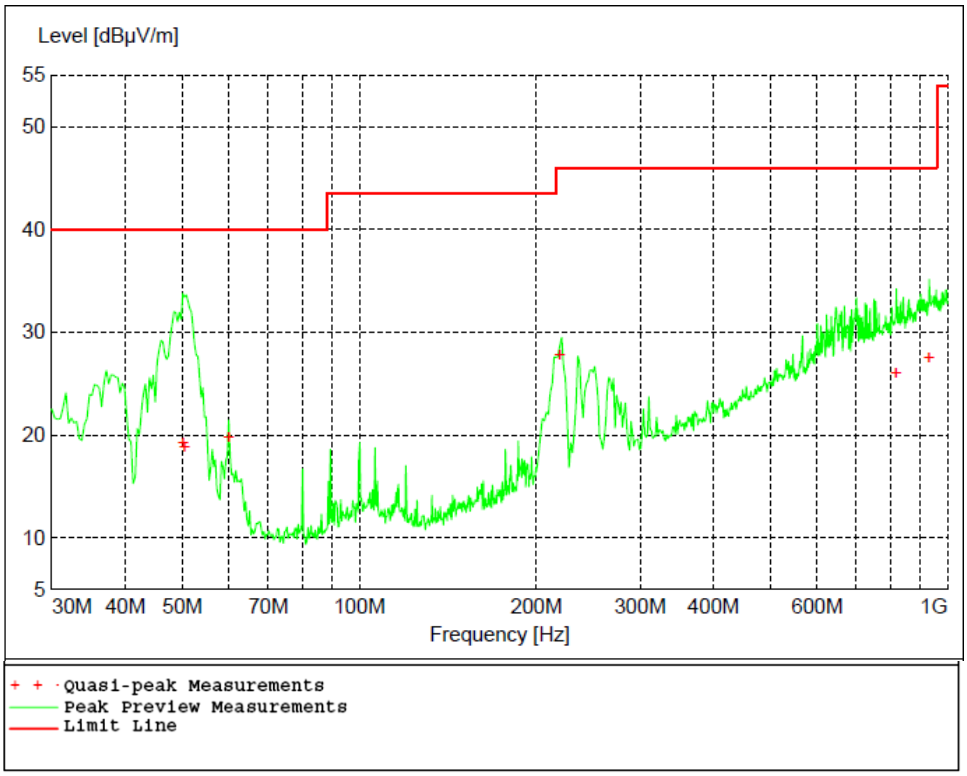

Figure 4 - Radiated Emissions Plot, Channel 1

Table 5 - Radiated Emissions Quasi-peak Measurements, Channel 1

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
50.160000	19.26	40.00	20.70	99	300	VERT
50.460000	18.80	40.00	21.20	101	271	VERT
60.000000	19.80	40.00	20.20	98	230	VERT
219.300000	27.71	46.00	18.30	100	263	HORI
817.800000	26.00	46.00	20.00	126	182	HORI
929.880000	27.49	46.00	18.50	298	253	VERT

Table 6 - Radiated Emissions Average Measurements, Channel 1

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
2452.400000	81.65	N/A	N/A	147	62	HORI
4905.000000	49.83	54.00	4.17	104	257	VERT
7312.000000	28.87	54.00	25.13	299	253	VERT
9814.400000	33.48	54.00	20.52	302	217	VERT
12244.400000	36.85	54.00	17.15	285	11	HORI
14702.000000	40.58	54.00	13.42	158	263	VERT
17120.800000	45.20	54.00	8.80	251	0	HORI

Table 7 - Radiated Emissions Peak Measurements, Channel 1

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
2452.400000	101.65	N/A	N/A	147	62	HORI
4905.000000	69.83	74.00	4.17	104	257	VERT
7312.000000	48.87	74.00	25.13	299	253	VERT
9814.400000	53.48	74.00	20.52	302	217	VERT
12244.400000	56.85	74.00	17.15	285	11	HORI
14702.000000	60.58	74.00	13.42	158	263	VERT
17120.800000	65.20	74.00	8.80	251	0	HORI

REMARKS:
1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB)
2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB)
3. The other emission levels were very low against the limit.
4. Margin value = Emission level – Limit value.
5. Average measurements were calculated from applying the averaging factors from Figures 2 – 4 to the peak measurements

EUT MODULE	i-Pilot Standard Head	MODE	Transmit, Ch 2 2457 MHz
INPUT POWER	24 VDC Battery	FREQUENCY RANGE	30MHz – 26 GHz
ENVIRONMENTAL CONDITIONS	26 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

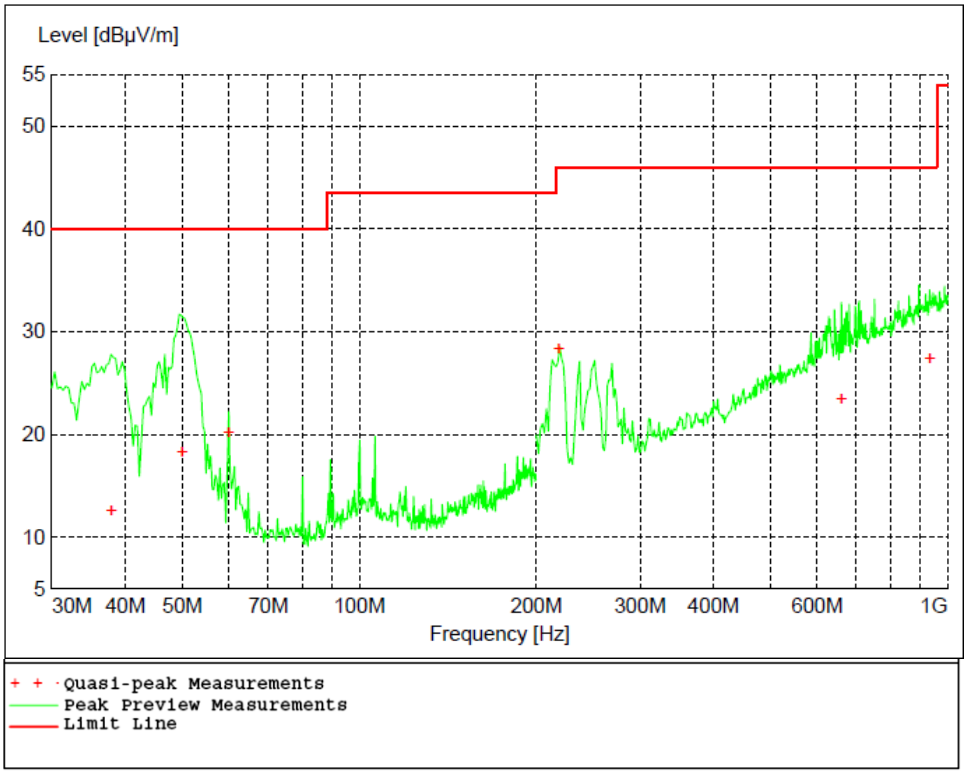

Figure 5 - Radiated Emissions Plot, Channel 2

Table 8 - Radiated Emissions Quasi-peak Measurements, Channel 2

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
37.920000	12.60	40.00	27.40	98	266	VERT
49.980000	18.29	40.00	21.70	101	312	VERT
60.000000	20.12	40.00	19.90	99	138	VERT
218.520000	28.32	46.00	17.70	101	266	HORI
660.600000	23.42	46.00	22.60	99	141	HORI
934.200000	27.31	46.00	18.70	162	357	HORI

Table 9 - Radiated Emissions Average Measurements, Channel 2

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
2457.400000	82.68	N/A	N/A	136	83	HORI
4913.000000	49.71	54.00	4.29	270	21	HORI
7369.200000	43.12	54.00	10.88	187	36	VERT
9832.600000	34.26	54.00	19.74	119	248	HORI
12301.000000	36.83	54.00	17.17	351	0	VERT
14729.200000	39.18	54.00	14.82	177	210	VERT
17172.200000	44.44	54.00	9.56	342	41	HORI

Table 10 - Radiated Emissions Peak Measurements, Channel 2

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
2457.400000	102.68	N/A	N/A	136	83	HORI
4913.000000	69.71	74.00	4.29	270	21	HORI
7369.200000	63.12	74.00	10.88	187	36	VERT
9832.600000	54.26	74.00	19.74	119	248	HORI
12301.000000	56.83	74.00	17.17	351	0	VERT
14729.200000	59.18	74.00	14.82	177	210	VERT
17172.200000	64.44	74.00	9.56	342	41	HORI

REMARKS:
1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB)
2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB)
3. The other emission levels were very low against the limit.
4. Margin value = Emission level – Limit value.
5. Average measurements were calculated from applying the averaging factors from Figures 2 – 4 to the peak measurements

EUT MODULE	i-Pilot Standard Head	MODE	Transmit, Ch 3 2462 MHz
INPUT POWER	24 VDC Battery	FREQUENCY RANGE	30MHz – 26 GHz
ENVIRONMENTAL CONDITIONS	26 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

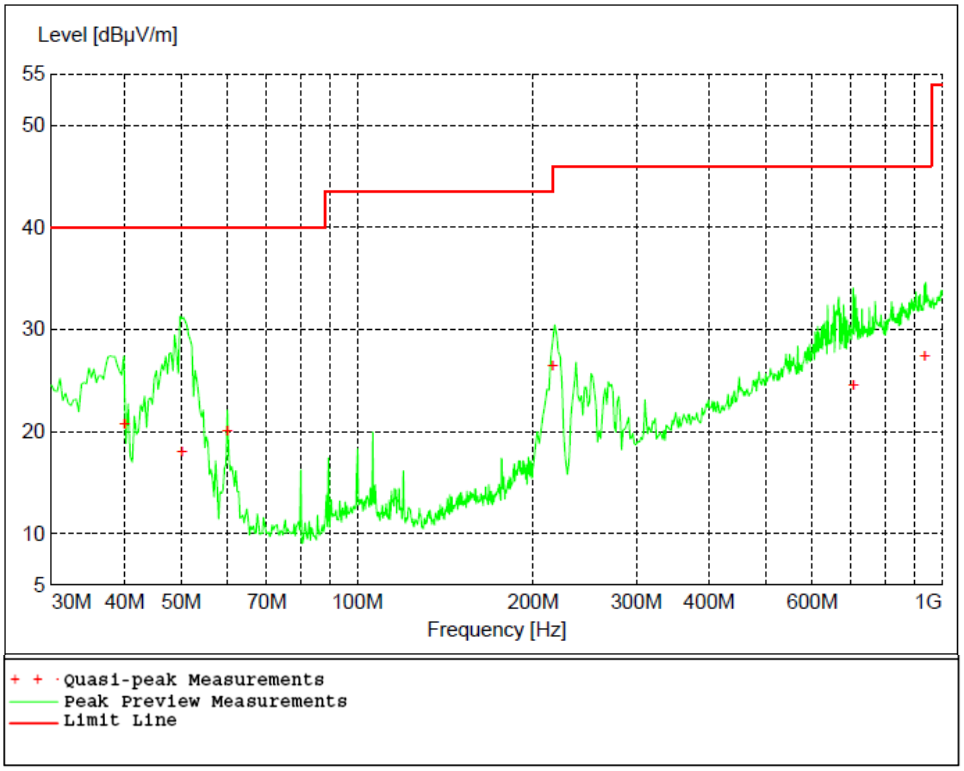

Figure 6 - Radiated Emissions Plot, Channel 3

Table 11 - Radiated Emissions Quasi-peak Measurements, Channel 3

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
40.020000	20.67	40.00	19.30	98	360	VERT
50.160000	17.97	40.00	22.00	99	318	VERT
60.000000	20.00	40.00	20.00	101	117	VERT
216.000000	26.37	43.50	17.20	99	261	HORI
706.500000	24.53	46.00	21.50	100	214	HORI
936.000000	27.39	46.00	18.60	179	354	HORI

Table 12 - Radiated Emissions Average Measurements, Channel 3

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
2461.400000	79.34	N/A	N/A	265	31	HORI
4925.000000	48.96	54.00	5.04	265	244	VERT
7332.600000	29.32	54.00	24.68	136	68	HORI
9803.000000	32.74	54.00	21.26	397	341	VERT
12313.000000	36.50	54.00	17.50	163	241	VERT
14681.200000	40.53	54.00	13.47	115	12	HORI
17156.200000	44.68	54.00	9.32	398	178	HORI

Table 13 - Radiated Emissions Peak Measurements, Channel 3

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
2461.400000	99.34	N/A	N/A	265	31	HORI
4925.000000	68.96	74.00	5.04	265	244	VERT
7332.600000	49.32	74.00	24.68	136	68	HORI
9803.000000	52.74	74.00	21.26	397	341	VERT
12313.000000	56.50	74.00	17.50	163	241	VERT
14681.200000	60.53	74.00	13.47	115	12	HORI
17156.200000	64.68	74.00	9.32	398	178	HORI

REMARKS:
1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB)
2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB)
3. The other emission levels were very low against the limit.
4. Margin value = Emission level – Limit value
5. Average measurements were calculated from applying the averaging factors from Figures 2 – 4 to the peak measurements

4.3 Bandwidth

4.3.1 Limits of bandwidth measurements

The 6dB bandwidth of the signal must be greater than 0.500MHz.

4.3.2 Test procedures

All measurements were taken at a distance of 3m from the EUT. The bandwidth of the fundamental frequency was measured by spectrum analyzer with 100 kHz RBW and 1 MHz VBW. The 6 dB bandwidth is defined as the bandwidth of which is higher than peak power minus 6dB.

The 99% occupied is defined as the bandwidth at which 99% of the signal power is found. This corresponds to 20dB down from the maximum power level. The maximum power was measured with the largest resolution bandwidth possible (10MHz) and this value was recorded. The signal was then captured with a 100kHz resolution bandwidth and the frequencies where the measurements were 20dB below the maximum power were marked. The bandwidth between these frequencies was recorded as the 99% occupied bandwidth.

4.3.3 Deviations from test standard

No deviation.

4.3.4 Test setup

See Section 4.2

4.3.5 EUT operating conditions

The EUT was powered by 24 VDC unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range.

4.3.6 Test results

EUT MODULE	i-Pilot Standard Head	MODE	Cont. Transmit
INPUT POWER	12 VDC Battery	FREQUENCY RANGE	2400.0MHz - 2483.5MHz
ENVIRONMENTAL CONDITIONS	26 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

CHANNEL	CHANNEL FREQUENCY (MHz)	6dB BW (MHz)	6dB Limit Min (kHz)	RESULT
1	2452	1.62	500.00	PASS
2	2457	1.94	500.00	PASS
3	2462	1.62	500.00	PASS

REMARKS:
None

CHANNEL	CHANNEL FREQUENCY (MHz)	99% Occupied BW (MHz)
1	2452	2.38
2	2457	2.42
3	2462	2.42

REMARKS:

None

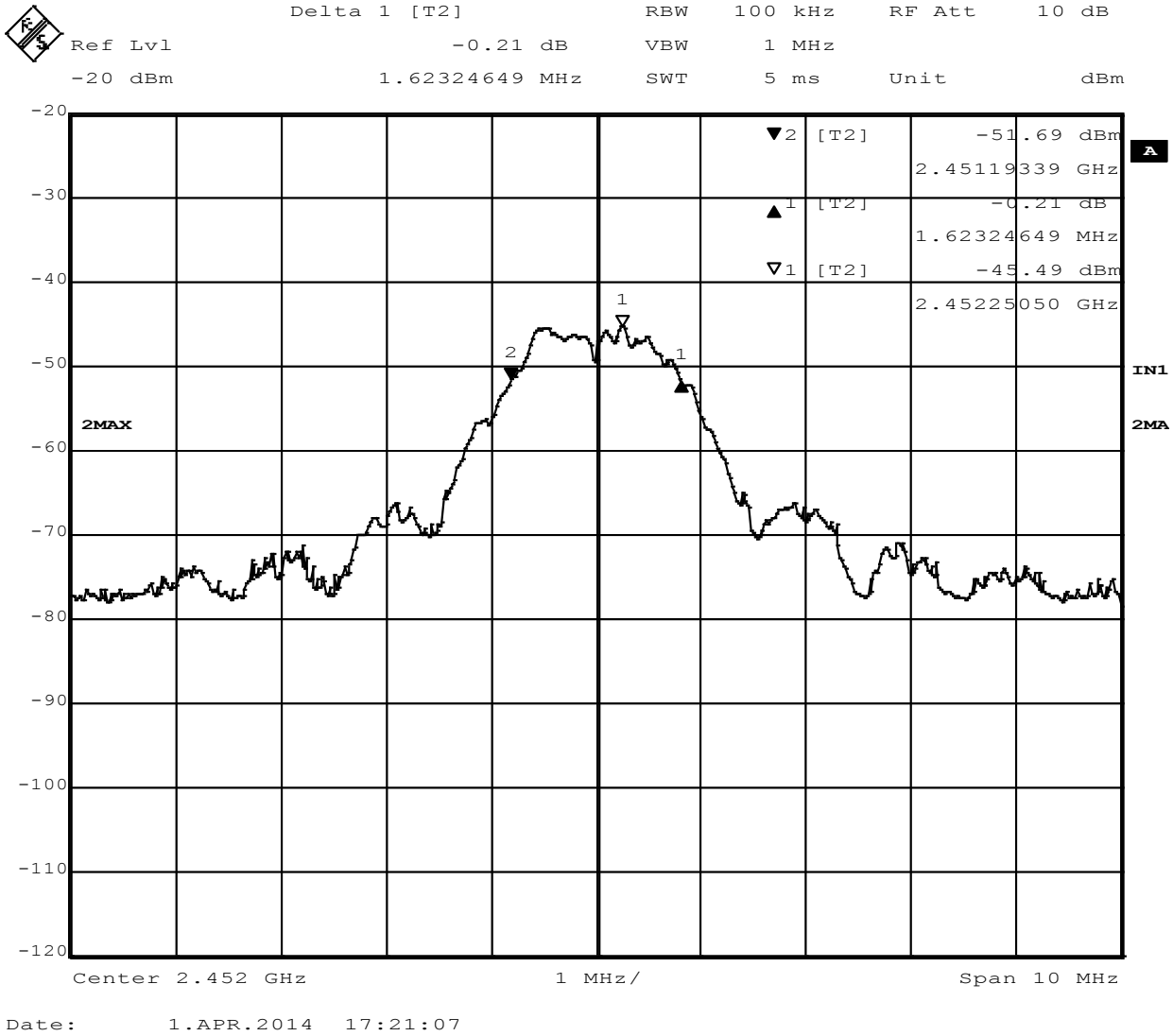

Figure 7 - 6dB Bandwidth, Low Channel

The plot shows an uncorrected measurement. Used for delta measurements only.

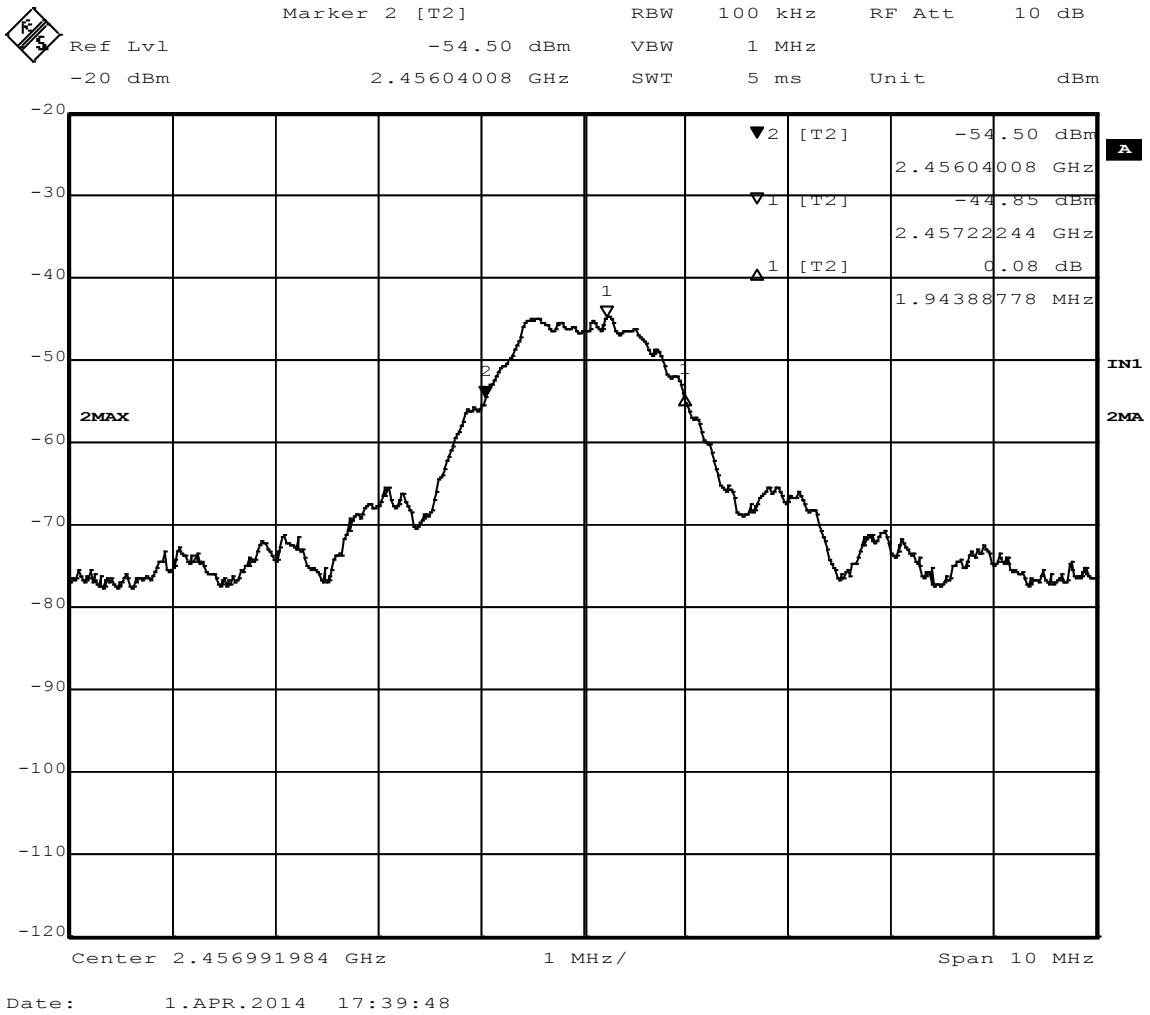

Figure 8 - 6dB Bandwidth, Middle Channel

The plot shows an uncorrected measurement. Used for delta measurements only.

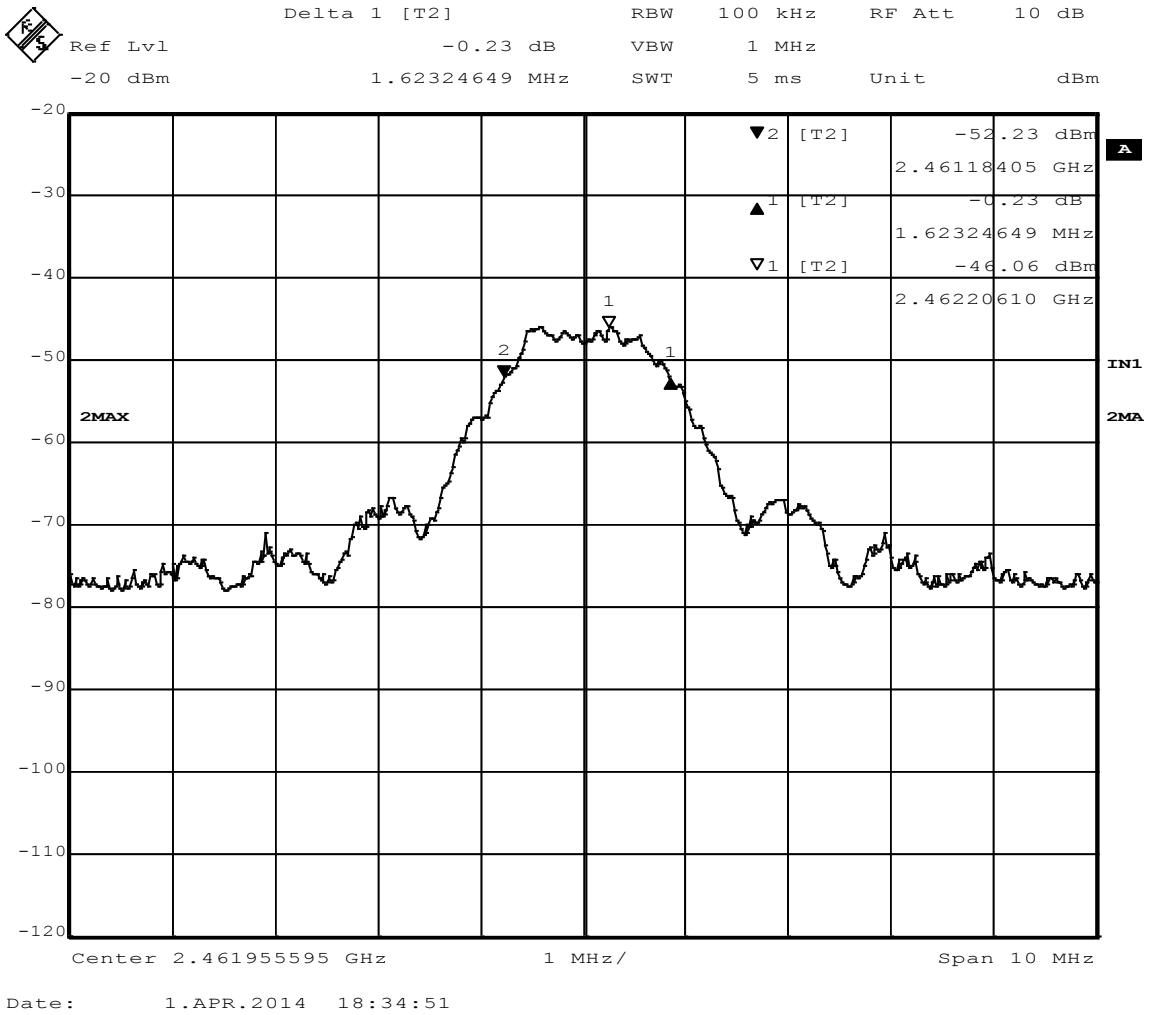

Figure 9 - 6dB Bandwidth, High Channel

The plot shows an uncorrected measurement. Used for delta measurements only.

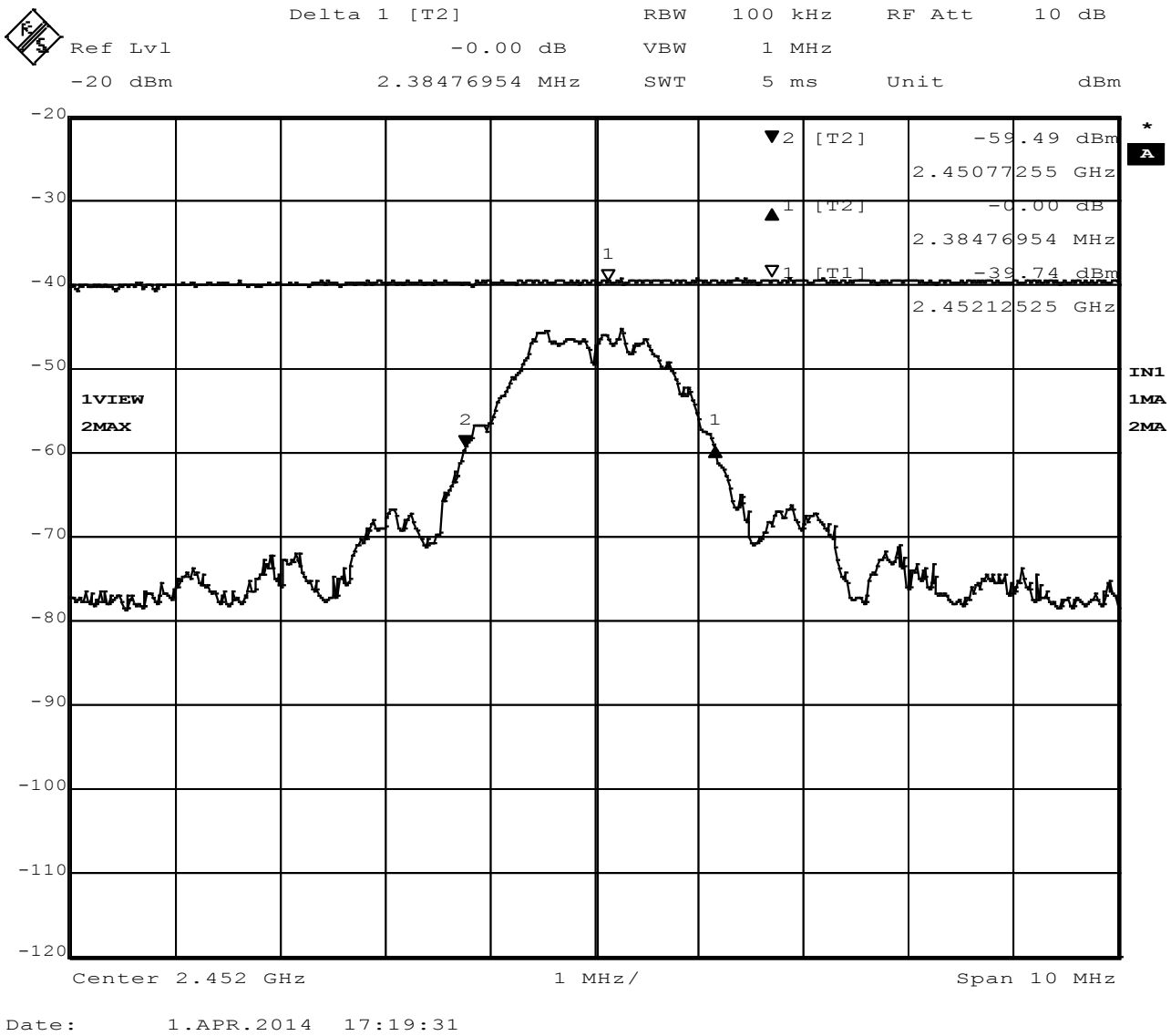

Figure 10 - 99% Occupied Bandwidth, Low Channel

The plot shows an uncorrected measurement.

Maximum power = -39.74 dBm + 107 + CL + AF - 95.23 = 7.65 dBm

CF = cable loss = 7.20 dB
AF = antenna factor = 28.47 dB
107 = conversion from dBm to dBµV on a 50Ω measurement system
-95.23 = Conversion from field strength (dBµV/m) to EIRP (dBm) at a 3m measurement distance.

Note: the trace at the top where Marker 1 is located was made with a 10MHz resolution bandwidth and saved on the screen.

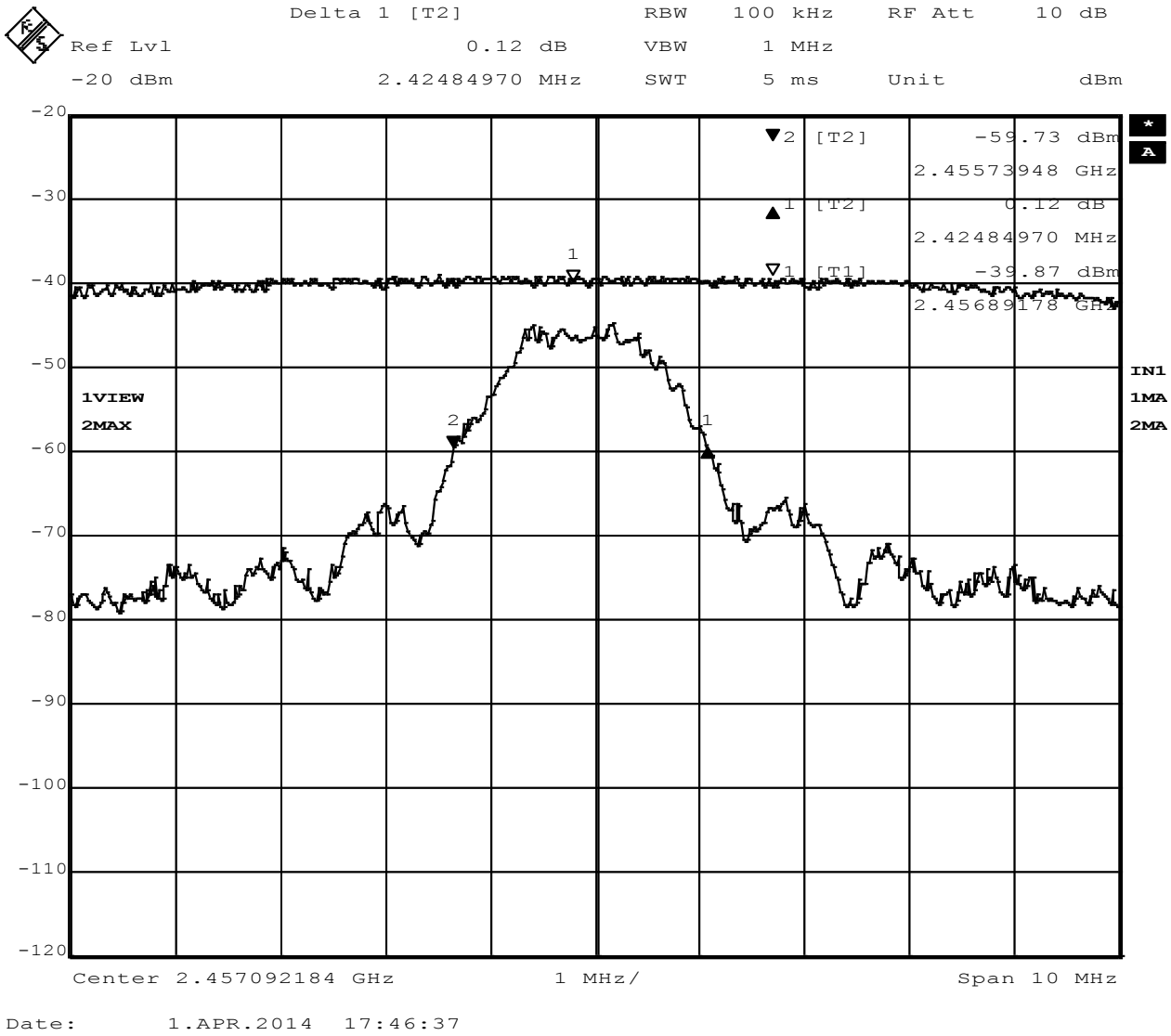

Figure 11 - 99% Occupied Bandwidth, Mid Channel

The plot shows an uncorrected measurement.

Maximum power = -39.87 dBm + 107 + CL + AF - 95.23 = 7.57 dBm

CF = cable loss = 7.20 dB
AF = antenna factor = 28.47 dB
107 = conversion from dBm to dBµV on a 50Ω measurement system
-95.23 = Conversion from field strength (dBµV/m) to EIRP (dBm) at a 3m measurement distance.

Note: the trace at the top where Marker 1 is located was made with a 10MHz resolution bandwidth and saved on the screen.

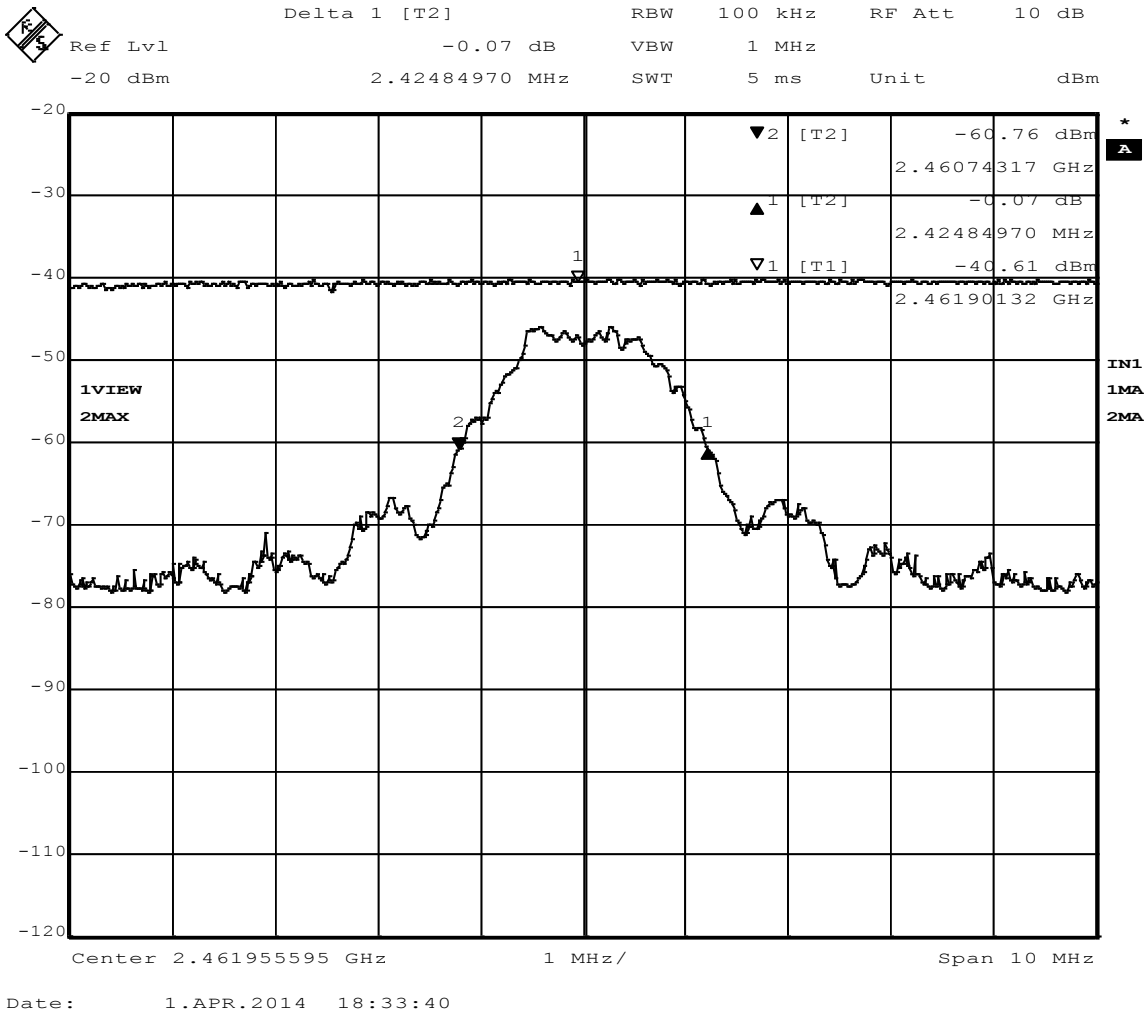

Figure 12 - 99% Occupied Bandwidth, High Channel
The plot shows an uncorrected measurement.

Maximum power = -40.61 dBm + 107 + CL + AF - 95.23 = 6.83 dBm

CF = cable loss = 7.20 dB
AF = antenna factor = 28.47 dB
107 = conversion from dBm to dBμV on a 50Ω measurement system
-95.23 = Conversion from field strength (dBμV/m) to EIRP (dBm) at a 3m measurement distance.

Note: the trace at the top where Marker 1 is located was made with a 10MHz resolution bandwidth and saved on the screen.

4.4 Maximum peak output power

4.4.1 Limits of power measurements

The maximum peak output power allowed is 30dBm (1000mW).

4.4.2 Test procedures

1. All measurements were taken at a distance of 3m from the EUT.

2. The resolution bandwidth was set to 10MHz and the video bandwidth was set to 10MHz to capture the maximum amount of signal. The analyzer used a peak detector in max hold mode. This represented the maximum output power.

3. See Annex B for an example of how the EIRP is calculated in order to report maximum power output.

4.4.3 Deviations from test standard

No deviation.

4.4.4 Test setup

See Section 4.2

4.4.5 EUT operating conditions

a 24 VDC battery supply and set to transmit continuously unless specified on the lowest frequency channel, highest frequency channel and one in the middle of its operating range.

4.4.6 Test results

EUT MODULE	i-Pilot Standard Head	MODE	Cont. Transmit
INPUT POWER	12 VDC Battery	FREQUENCY RANGE	2400.0MHz - 2483.5MHz
ENVIRONMENTAL CONDITIONS	26 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

Maximum peak output power

CHANNEL	CHANNEL FREQUENCY (MHz)	EIRP PEAK POWER OUTPUT (dBm)	PEAK POWER LIMIT (dBm)	RESULT
1	2452	7.65	30	PASS
2	2457	7.57	30	PASS
3	2462	6.83	30	PASS

All measurements were taken from the 99% occupied bandwidth screen captures in Section 4.3.

REMARKS:

Section 4.3 gives the peak radiated field strength in dBm without correction factors

FS (dBµV/m) = FS (dBm) + 107 + CL + AF (50Ω measurement system)

CL = Cable loss (see section 4.2.2 or Appendix B for values)
AF = Antenna factor (see section 4.2.2 or Appendix B for values)
FS = Field strength

EIRP (Watts) = [Field Strength (V/m) x antenna distance (m)]^2 / [30 x Gain (numeric)]

For an antenna distance of 3m and a numeric antenna gain of zero,

EIRP (dBm) = FS (dBµV/m) – 95.23

4.5 Bandedges

4.5.1 Limits of bandedge measurements

For emissions outside of the allowed band of operation (2400.0MHz – 2483.5MHz), the emission level needs to be 20dB under the maximum fundamental field strength. However, if the emissions fall within one of the restricted bands from 15.205 the field strength levels need to be under that of the limits in 15.209.

4.5.2 Test procedures

The EUT was tested in the same method as described in section *4.3 - Bandwidth*. The EUT was oriented as to produce the maximum emission levels. The resolution bandwidth was set to 120kHz and the EMI receiver was used to scan from the bandedge to the fundamental frequency with a quasi-peak detector. The highest emissions level beyond the bandedge was measured and recorded. If the out of band emissions do not fall within a restricted band from 15.205, then it is required that the out of band emission be 20dB below that of the fundamental emission level. If the out of band emission falls with a restricted band from 15.205, then it is required that the emission be below the limits from 15.209.

4.5.3 Deviations from test standard

No deviation.

4.5.4 Test setup

See Section 4.4

4.5.5 EUT operating conditions

The EUT was powered by a 24 VDC battery supply unless specified and set to transmit continuously on the lowest frequency channel and the highest frequency channel.

4.5.6 Test results

EUT MODULE	i-Pilot Standard Head	MODE	Cont. Transmit
INPUT POWER	12 VDC Battery	FREQUENCY RANGE	2400.0MHz - 2483.5MHz
ENVIRONMENTAL CONDITIONS	26 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

Highest Out of Band Emissions

CHANNEL	Band edge /Measurement Frequency (MHz)	Highest out of band level dBm	Fundamental Level (dBm)	Delta	Min (dBc)	Result
1	2360.0	-106.23	-50.47	55.76	47.65*	PASS
3	2483.5	-105.22	-50.21	55.01	45.34*	PASS

Highest In-Band Emissions

CHANNEL	Band edge /Measurement Frequency (MHz)	Highest in-band level dBm	Fundamental Level (dBm)	Delta	Min (dBc)	Result
1	2400.0	-106.79	-50.47	56.32	20.2	PASS
3	2483.5	-105.22	-50.21	55.01	20.0	PASS

*Minimum delta = [highest fundamental peak field strength from Section 4.2] – [Part 15.209 radiated emissions limit.]

Measurements do not include correction factors

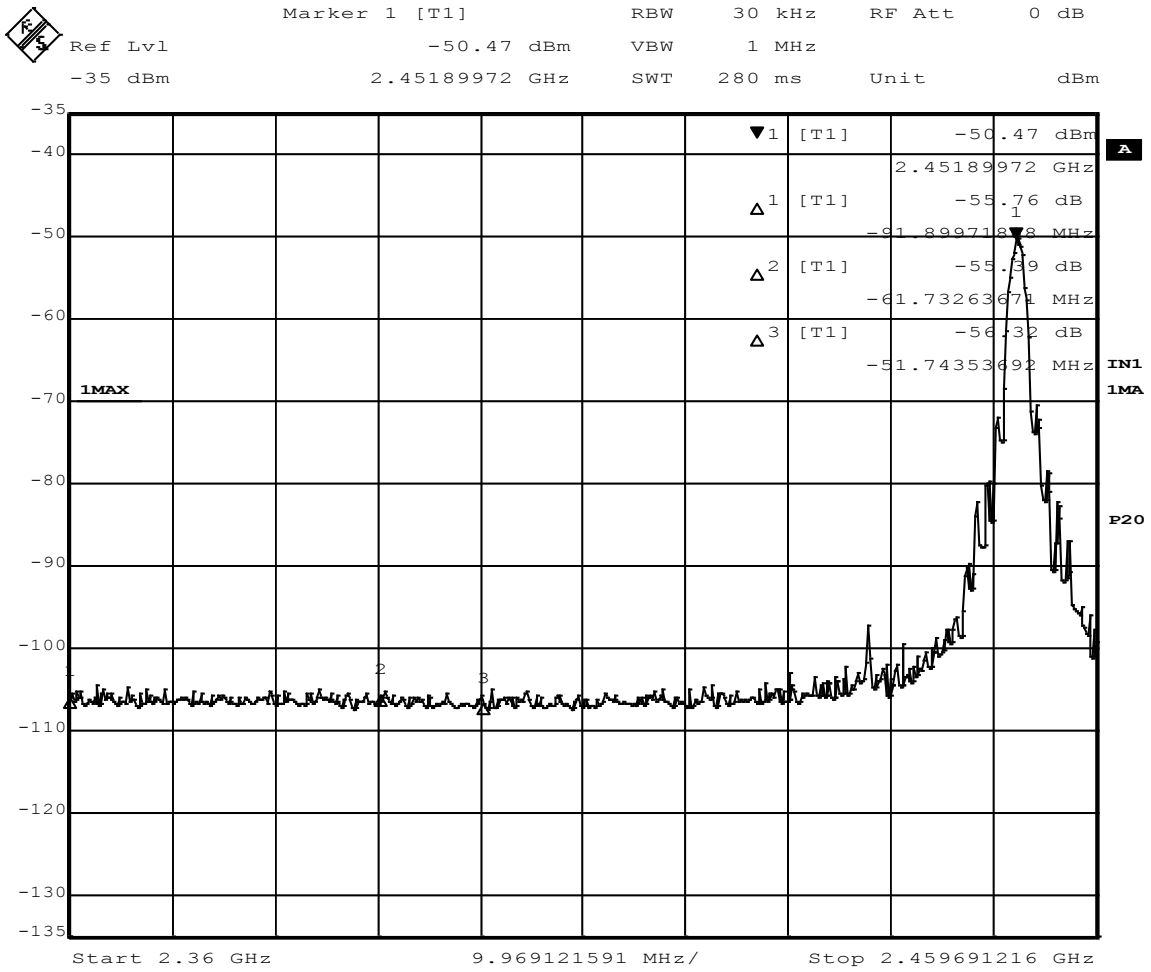

Figure 13 - Band-edge Measurement, Low Channel

The plot shows an uncorrected measurement. Used for delta measurements only.

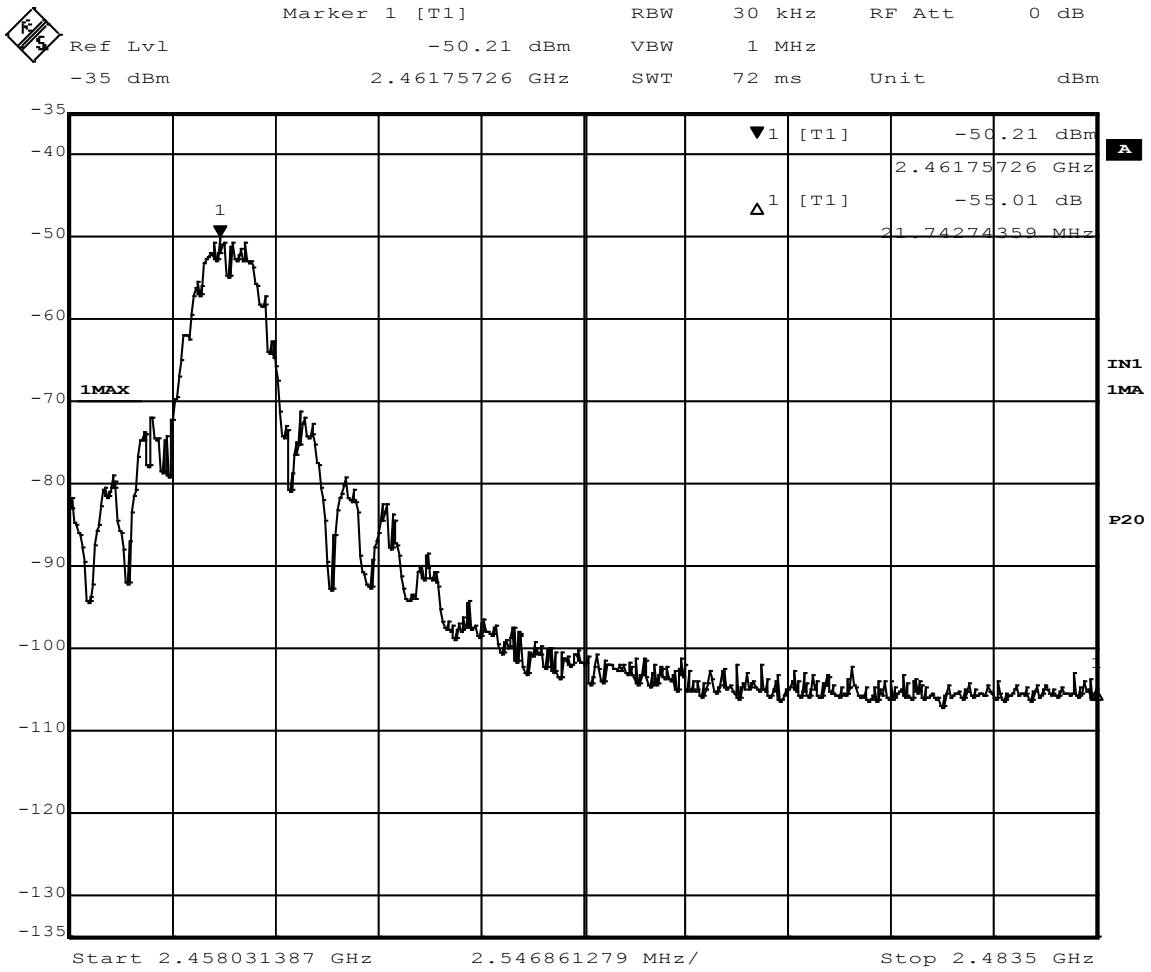

Figure 14 - Band-edge Measurement, High Channel

The plot shows an uncorrected measurement. Used for delta measurements only.

4.6 Power Spectral Density

4.6.1 Power spectral density measurements

For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

4.6.2 Test procedures

All measurements were taken at a distance of 3m from the EUT. The spectrum analyzer was set to 3 kHz RBW and 30 kHz VBW, the sweep time was set to auto. The power spectral density was measured and recorded at the frequency with the highest emission. The sweep time is allowed to be longer than span/3KHz for a full response of the mixer in the spectrum analyzer.

See Annex B for an example of how the EIRP is calculated in order to report maximum power output.

4.6.3 Deviations from test standard

No deviation.

4.6.4 Test setup

See section 4.3

4.6.5 EUT operating conditions

The EUT was powered by a 24 VDC battery supply unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range.

EUT MODULE	i-Pilot Standard Head	MODE	Cont. Transmit
INPUT POWER	12 VDC Battery	FREQUENCY BAND	2400.0MHz - 2483.5MHz
ENVIRONMENTAL CONDITIONS	26 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

Power Spectral Density

CHANNEL	CHANNEL FREQUENCY (MHz)	EIRP RF POWER LEVEL IN # KHz BW (dBm)	MAXIMUM POWER LIMIT (dBm)	RESULT
1	2452	-8.19	8.00	PASS
2	2457	-7.96	8.00	PASS
3	2462	-8.91	8.00	PASS

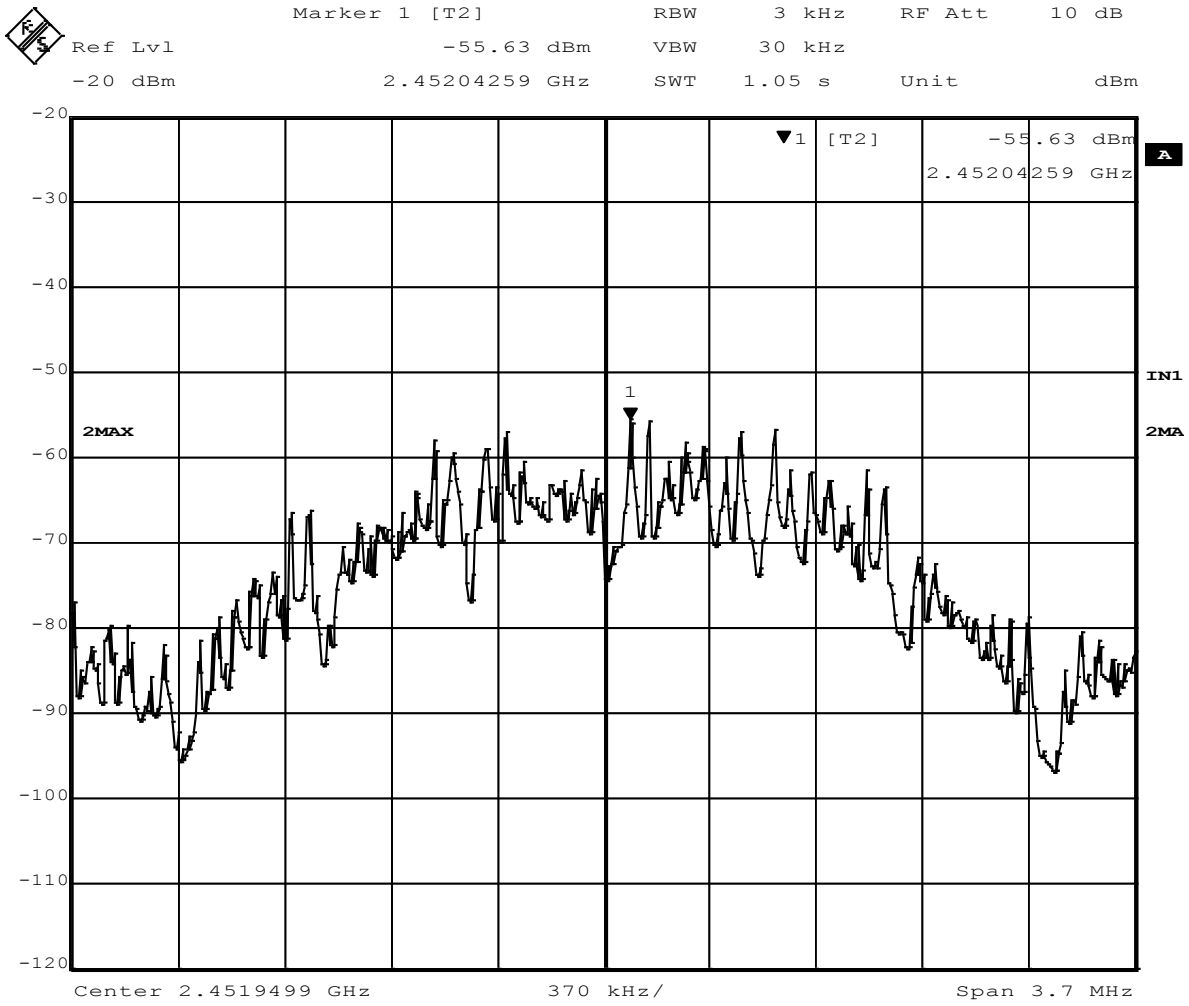

Figure 15 - Power Spectral Density Measurement, Low Channel
The plot shows an uncorrected measurement.

Maximum PSD = -55.63 dBm + 107 + CL + AF - 95.23 = -8.19 dBm

CF = cable loss = 7.20 dB
AF = antenna factor = 28.47 dB
107 = conversion from dBm to dBµV on a 50Ω measurement system
-95.23 = Conversion from field strength (dBµV/m) to EIRP (dBm) at a 3m measurement distance.

Note: the trace at the top where Marker 1 is located was made with a 10MHz resolution bandwidth and saved on the screen.

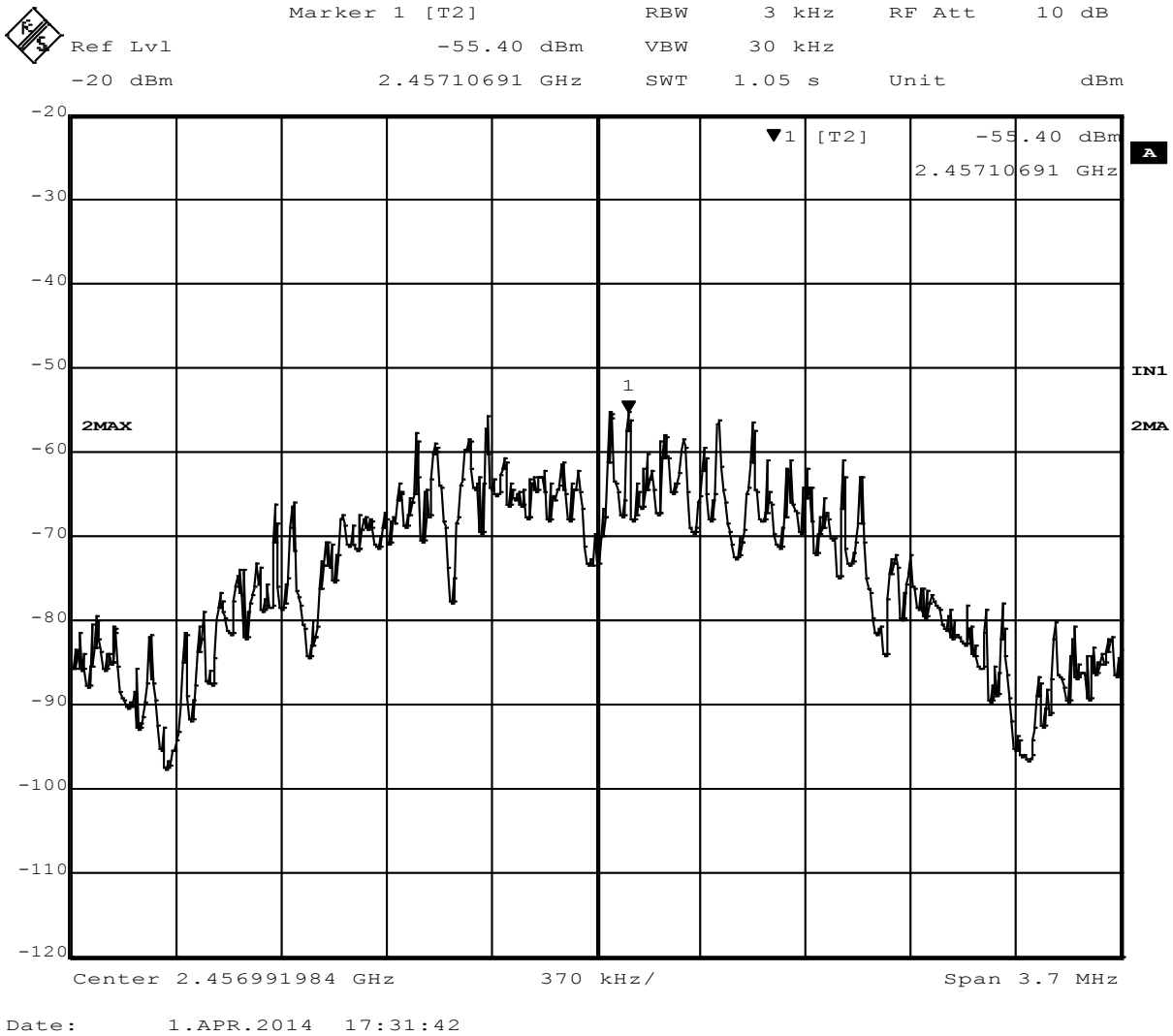

Figure 16 - Power Spectral Density Measurement, Mid Channel

The plot shows an uncorrected measurement.

Maximum PSD = -55.40 dBm + 107 + CL + AF - 95.23 = -7.96 dBm

CF = cable loss = 7.20 dB
AF = antenna factor = 28.47 dB
107 = conversion from dBm to dBμV on a 50Ω measurement system
-95.23 = Conversion from field strength (dBμV/m) to EIRP (dBm) at a 3m measurement distance.

Note: the trace at the top where Marker 1 is located was made with a 10MHz resolution bandwidth and saved on the screen.

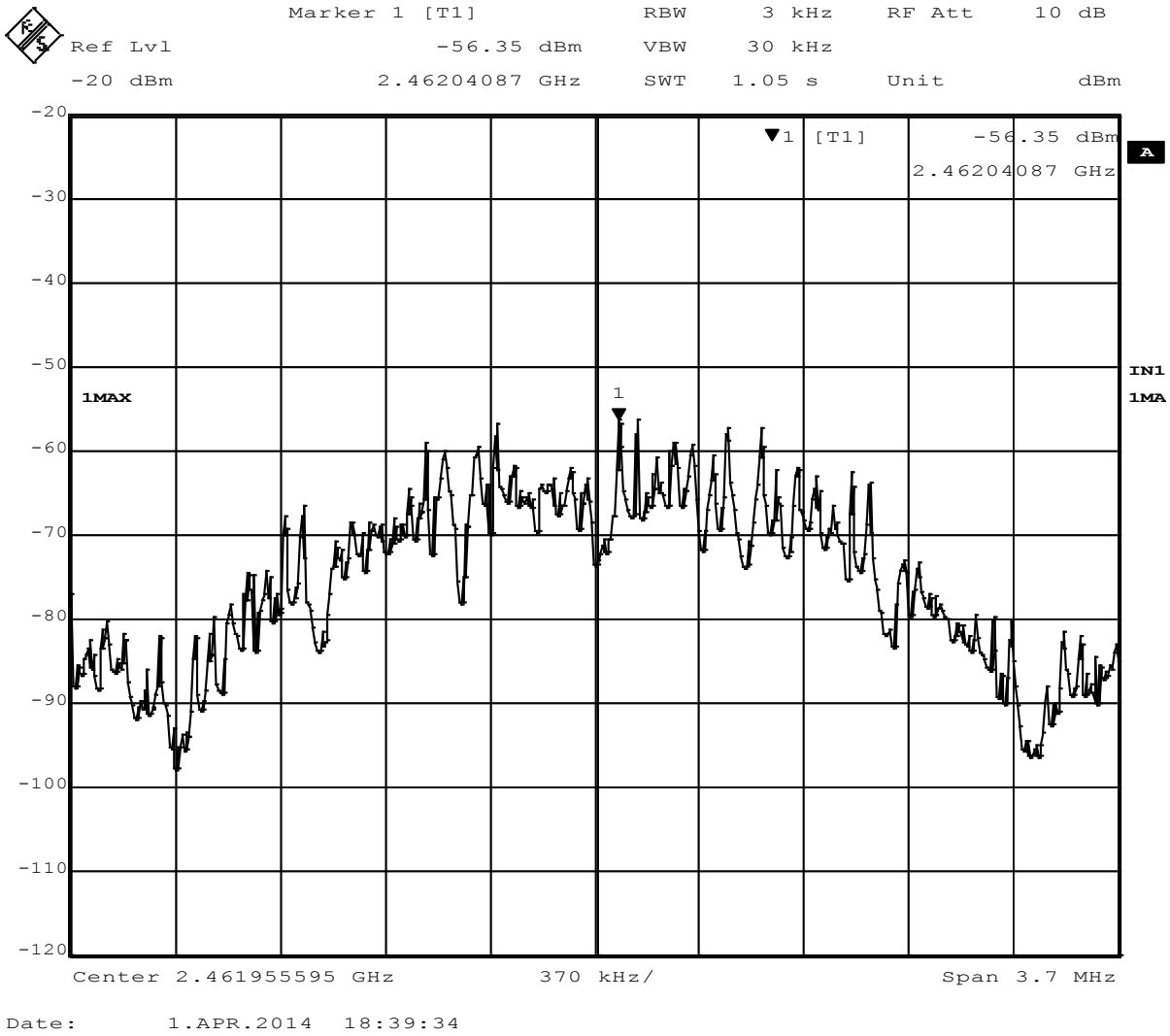

Figure 17 - Power Spectral Density Measurement, High Channel

The plot shows an uncorrected measurement.

Maximum PSD = -56.35 dBm + 107 + CL + AF - 95.23 = -8.91 dBm

CF = cable loss = 7.20 dB
AF = antenna factor = 28.47 dB
107 = conversion from dBm to dBμV on a 50Ω measurement system
-95.23 = Conversion from field strength (dBμV/m) to EIRP (dBm) at a 3m measurement distance.

Note: the trace at the top where Marker 1 is located was made with a 10MHz resolution bandwidth and saved on the screen.

Appendix A: Test Photos

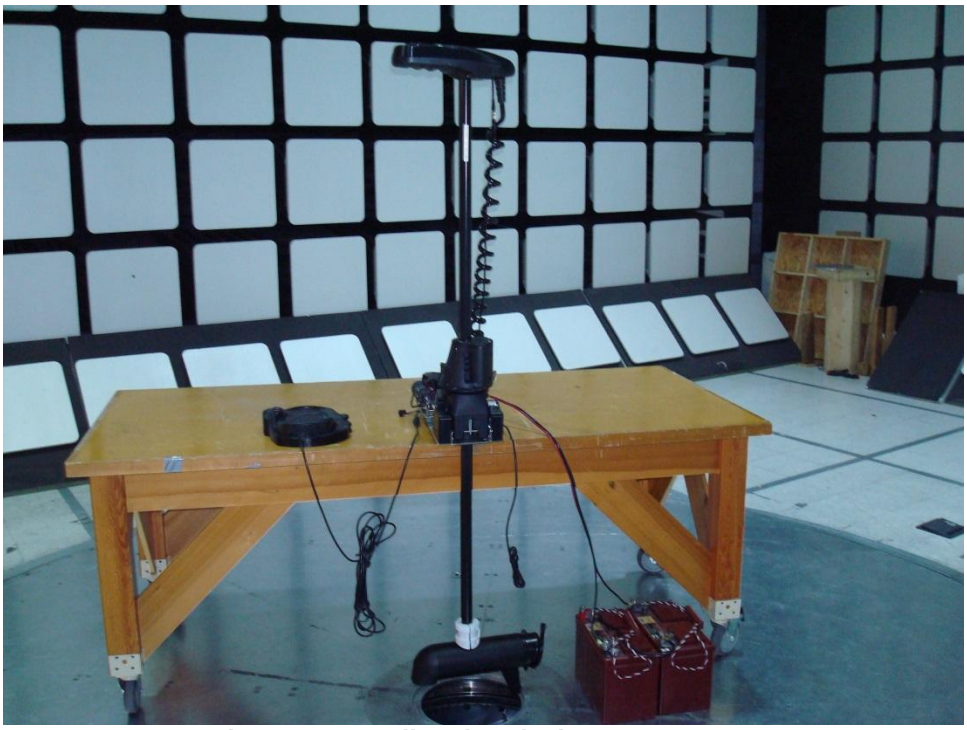

Figure 18 – Radiated Emissions Test Setup

Figure 19 - Radiated Emissions Test Setup

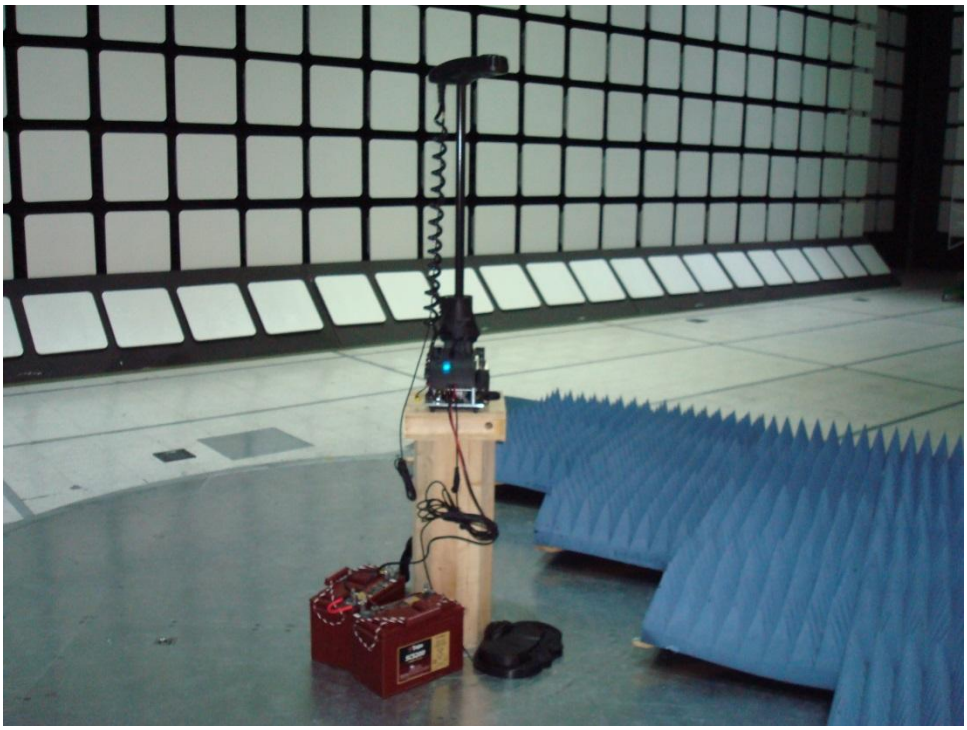

Figure 20 - Radiated Emissions Test Setup

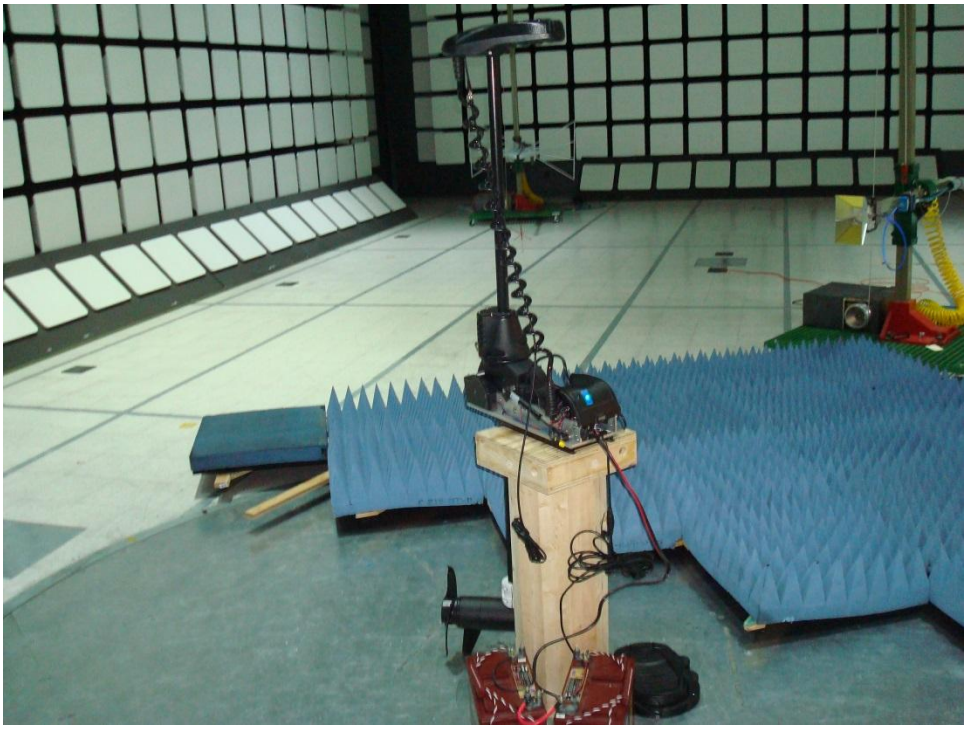

Figure 21 - Radiated Emissions Test Setup

Appendix B: Sample Calculation

Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and Cable Factor, and subtracting the Amplifier Gain (if any) from the measured reading. The basic equation with a sample calculation is as follows:
FS = RA + AF – (-CF + AG) + AV

where FS = Field Strength

RA = Receiver Amplitude

AF = Antenna Factor

CF = Cable Attenuation Factor

AG = Amplifier Gain

AV = Averaging Factor (if applicable)

Assume a receiver reading of 55 dBμV is obtained. The Antenna Factor of 12 and a Cable Factor of 1.1 is added. The Amplifier Gain of 20 dB is subtracted, giving a field strength of 48.1 dBμV/m.

FS = 55 + 12 – (-1.1 + 20) + 0 = 48.1 dBμV/m

The 48.1 dBμV/m value can be mathematically converted to its corresponding level in μV/m.

Level in μV/m = Common Antilogarithm [(48.1 dBμV/m)/20]= 254.1 μV/m

AV is calculated by the taking the 20*log(T_{on}/100) where T_{on} is the maximum transmission time in any 100ms window.

EIRP Calculations

In cases where direct antenna port measurement is not possible or would be inaccurate, output power is measured in EIRP. The maximum field strength is measured at a specified distance and the EIRP is calculated using the following equation;

EIRP (Watts) = [Field Stregnth (V/m) x antenna distance (m)]^2 / [30 x Gain (numeric)]

Power (watts) = 10^[Power (dBm)/10] x 1000

Field Strength (dBµV/m) = Field Stregth (dBm) + 107 (for 50Ω measurement systems)

Field Stregnth (V/m) = 10^[Field Stregnth (dBµV/m) / 20] / 10^6

Gain = 1 (numeric gain for isotropic radiator

For an antenna distance of 3m and a numeric antenna gain of zero,

EIRP (dBm) = FS (dBµV/m) – 95.23

Table 14 – Correction Factor Applied in Sections 4.3, 4.4 and 4.6

CHANNEL	CHANNEL FREQUENCY (MHz)	ANTENNA FACTOR	CABLE LOSS
1	2452	28.47	7.20
2	2457	28.47	7.20
3	2462	28.47	7.20

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